INTERNATIONAL STANDARD

ISO 11613

First edition
1999-12-15

Protective clothing for firefighters — Laboratory test methods and performance requirements

Vêtements de protection pour sapeurs-pompiers — Méthodes d'essai et exigences de performance

Reference number
ISO 11613:1999(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 734 10 79
E-mail copyright@iso.ch
Web www.iso.ch

Printed in Switzerland

Contents

Page

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 11613 was prepared by Technical Committee ISO/TC 94, *Personal safety — Protective clothing and equipment*, Subcommittee SC 13, *Protective clothing*.

Annexes A, B, C, D and E form a normative part of ISO 11613. Annexes F and G are for information only.

Introduction

The purpose of this International Standard is to provide minimum performance requirements for protective clothing designed to protect against injury in firefighting operations. It provides guidance on the selection of firefighters' protective clothing (see clause 1) and considerations for conducting a risk assessment of firefighting risks (see annex F).

Two alternative approaches to the design and performance requirements for firefighting clothing are provided.

Approach A Clause 4 specifies design and performance requirements based on EN 469 *Protective Clothing for Firefighters — Requirements and test methods for protective clothing for firefighting* and its clarification documents.

Approach B Clause 5 specifies design and performance requirements based on NFPA 1971 *Standard on Protective Clothing for Structural Firefighting.*

A comparison of the requirements in clauses 4 and 5 is given in annex G. The two approaches are not directly comparable as they use different test procedures.

This International Standard has been prepared to fulfil the requirements of a number of countries and it combines both European and North American approaches. It is agreed that a revision of this International Standard will start immediately after its publication in order to specify levels of performance on single test methods and to take into account any changes in revision of both EN 469 and NFPA 1971.

Nothing in this International Standard is intended to restrict any jurisdiction, purchaser or manufacturer from exceeding these minimum requirements.

Protective clothing for firefighters — Laboratory test methods and performance requirements

1 Scope

This International Standard specifies test methods and minimum requirements for protective clothing to be worn during firefighting and associated activities where there is a risk of heat and/or flame.

This International Standard covers the general clothing design, the minimum performance levels of the materials used, and the methods of test for determining these performance levels. Clauses 4 and 5 define two separate sets of design and performance requirements.

This International Standard does not cover special clothing for use in other high risk situations such as specialized firefighting, or clothing for use in long term firefighting operations in high ambient temperature, for example brush, wildland, or forest firefighting. It does not cover protection for the head, hands and feet or protection against other hazards, for example chemical, biological, radiation and electrical hazards. These aspects may be dealt with in other standards.

Selection of the appropriate system of clothing is dependent on carrying out an effective risk assessment which identifies the hazards to be faced, evaluates the likelihood of those hazards, and provides the means to reduce or eliminate these hazards. Details on one example at a recommended risk assessment approach and some factors for consideration are included in annex F.

NOTE Additional personal protective equipment to protect the head, hands, and feet should be worn with clothing specified in this International Standard and in majority of situations breathing apparatus is also required to be worn. Firefighters should be trained in the use and care of protective clothing covered by this International Standard including an understanding of its limitations and of the other items of personal protective equipment that may be required depending on the risks encountered.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 811:1981, *Textile fabrics — Determination of resistance to water penetration — Hydrostatic pressure test.*

ISO 3146:1985, *Plastics — Determination of melting behaviour (melting temperature or melting range) of semi-crystalline polymers.*

ISO 3175-2:1998, *Textiles — Dry cleaning and finishing — Part 2: Procedures for tetrachloroethene.*

ISO 4674:1977, *Fabrics coated with rubber or plastics — Determination of tear resistance.*

ISO 4920:1981, *Textiles — Determination of resistance to surface wetting (spray test) of fabrics.*

ISO 5077:1984, *Textiles — Determination of dimensional change in washing and drying.*

ISO 5081:1977, *Textiles — Woven fabrics — Determination of breaking strength and elongation (Strip method).*

ISO 5082:1982, *Textiles — Woven fabrics — Determination of breaking strength — Grab method.*

ISO 6330:1984, *Textiles — Domestic washing and drying procedures for textile testing.*

ISO 6530:1990, *Protective clothing — Protection against liquid chemicals — Determination of resistance of materials to penetration by liquids.*

ISO 6942:1993, *Clothing for protection against heat and fire — Evaluation of thermal behaviour of materials and material assemblies when exposed to a source of radiant heat.*

ISO 9073-4:1997, *Textiles — Test methods for nonwovens — Part 4: Determination of tear resistance.*

ISO 9151:1995, *Protective clothing against heat and flame — Determination of heat transmission on exposure to flame.*

ISO 9227:1990, *Corrosion tests in artificial atmospheres — Salt spray tests.*

ISO 13688:1998, *Protective clothing — General requirements.*

ISO 15025:—[1], *Protective clothing — Protection against heat and flame — Method of test for limited flame spread.*

ISO 17492:—[1], *Clothing for protection against heat and flame — Determination of heat transmission on exposure to both flame and radiant heat.*

ISO 17493:—[1], *Clothing for protection against heat and flame — Determination of convective heat resistance using a hot air circulating oven.*

EN 532:1994, *Protective clothing — Protection against heat and flame — Test method for limited flame spread.*

ASTM E 809:1981, *Standard Practice for Measuring Photometric Characteristics of Retroreflectors.*

3 Terms, definitions and symbols

For the purposes of this International Standard, the following terms, definitions and symbols apply.

3.1 Terms and definitions

3.1.1
cargo pockets
pockets located on the protective garment exterior

NOTE As used in clause 5.

3.1.2
char
formation of a brittle residue when material is exposed to thermal energy

3.1.3
collar lining
that part of the collar fabric composite that is next to the skin when the collar is closed in the raised position

---

[1] To be published.

3.1.4
composite
layer or layers that provide protection required of outer shell, moisture barrier, and thermal barrier

3.1.5
closure system
method of fastening openings in the garment including combinations of more than one method of achieving a secure closure, for example a slide fastener covered by an overlap fastened down with a touch and close fastener

NOTE This term does not cover seams.

3.1.6
component assembly
material combination found in a multilayer garment arranged in the order of the finished garment construction and including any inner liner

3.1.7
drip
to run or fall in drops or blobs

3.1.8
firefighters' protective clothing
specific garments providing protection for the firefighter's upper and lower torso, neck, arms, and legs, but excluding the head, hands, and feet

3.1.9
garment
single item of clothing which may consist of single or multiple layers

3.1.10
hardware
non-fabric components of protective clothing including those made of metal or plastic material

NOTE Examples include fasteners, rank markings, buttons, etc.

3.1.11
innermost lining
lining found on the innermost face of a component assembly

3.1.12
integral melting
liquefaction of a material when exposed to heat to the extent of causing a hole in its structure, either by shrinking and/or dripping away under specified test conditions

NOTE See 5.1 and 5.5.

3.1.13
interface area
area of the body not protected by a protective garment, helmet, gloves, footwear, or self-contained breathing apparatus (SCBA) facepiece; the area where the protective garments and the helmet, gloves, footwear, or SCBA facepiece meet, i.e., the protective coat/helmet/SCBA facepiece area, the protective coat/glove area, and the protective trouser/footwear area

3.1.14
interface component
item(s) designed to provide limited protection to interface areas

3.1.15
interlining
layer found between the outermost layer and the innermost lining in a multilayer garment, not next to the wearer's skin

3.1.16
manufacturer
entity that assumes the liability and provides the warranty for the compliant product

NOTE As used in clause 5.

3.1.17
material combination
material produced from a series of separate layers, intimately combined prior to the garment manufacturing stage

EXAMPLE A quilted fabric.

3.1.18
melt
to change from solid to liquid form, or become consumed by action of heat

3.1.19
moisture barrier
that portion of the protective garment designed to prevent the transfer of liquid water from the environment to the thermal barrier

NOTE As used in clause 5.

3.1.20
moisture barrier
fabric or membrane used in a component assembly to enable the properties of the assembly to comply with the manufacturer's claims concerning hydrostatic pressure and water vapour permeability

NOTE As used in clause 4.

3.1.21
multilayer clothing assembly
series of layers of garments arranged in the order as worn

NOTE It may contain multilayer materials, material combinations or separate layers of clothing material in single layers.

3.1.22
outer material
outermost material of which the protective clothing is made

3.1.23
outer shell
outside facing portion of the composite with the exception of trim, hardware, reinforcing material, and wristlet material

NOTE As used in clause 5.

3.1.24
protective clothing
protective garments, configured as a coat and trousers or as a coverall, and interface components that are designed to provide protection to the firefighter's body

3.1.25
protective coat
protective garment designed and configured to provide protection to upper torso and arms, excluding the hands and head

3.1.26
protective coverall
protective garment designed and configured to provide protection to the torso, arms, and legs, excluding the head, hands, and feet

3.1.27
protective garment
single item of clothing which may consist of single or multiple layers, for example protective coat, protective trouser, or protective coverall

3.1.28
protective hood
interface component that provides limited protection to the protective coat/helmet/SCBA facepiece interface area

3.1.29
protective trouser
provides protection to lower torso and legs excluding the feet

3.1.30
protective uniform garment
garment designed and configured to be both the thermal barrier or portion of the thermal barrier of a protective garment, and a station/work uniform

NOTE 1 As used in clause 5.

NOTE 2 The term refers specifically to station/work uniform garments that satisfy the applicable requirements of NFPA 1975, *Standard on Station/Work Uniforms for Firefighters*, and that also satisfy in part or in full the thermal barrier requirements of this International Standard.

3.1.31
protective wristlet
interface component that provides limited protection to the protective garment/glove interface area

3.1.32
removable inner liner
inner garment designed to be attached or to be worn separately under an outer garment in order to provide thermal insulation

3.1.33
seam
junction of two edges of material which are permanently attached in the garment by sewing or any other method

3.1.33.1
major A seams
outer-shell seam assemblies where rupture could reduce the protection of the garment by exposing the moisture barrier, thermal barrier, the wearer's station/work uniform, other clothing, or skin

NOTE As used in clause 5.

3.1.33.2
major B seams
moisture barrier or thermal barrier seam assemblies where rupture could reduce the protection of the garment by exposing the next layer of the garment, the wearer's station/work uniform, other clothing, or skin

NOTE As used in clause 5.

3.1.33.3
minor seams
remaining seam assemblies that are not classified as major A or major B seams

3.1.34
thermal barrier
that portion of the composite designed to provide thermal protection

3.1.35
trim
retroreflective and fluorescent material attached to the outer shell for visibility enhancement; retroreflective materials enhance night-time visibility, and fluorescent materials improve daytime visibility

3.1.36
undergarment
garment which is worn under an outer garment

3.1.37
winter liner
optional composite layer designed to provide added insulation against cold

3.2 Symbols and subscripts

3.2.1 Symbols

A_r total retroreflective trim surface area

A_p total surface area of the plate

C_l coefficient of luminous intensity

C_r coefficient of reflectivity

H heat power input

I_m permeability index

I_Q heat transmission index

I_T thermal protection index

m mass

p water pressure

p_a water pressure of the ambient environment

p_p water pressure at the plate surface

Q_tot total heat loss

R_e evaporative resistance

$R_\mathrm{e,in}$ intrinsic evaporative resistance of the test specimen

$R_{e,p}$ evaporative resistance of the bare plate

$R_{e,tot}$ total evaporative resistance

R_T thermal resistance

$R_{T,in}$ intrinsic thermal resistance of the test specimen

$R_{T,p}$ thermal resistance of the bare plate

$R_{T,tot}$ total thermal resistance

T temperature

T_a temperature of the ambient environment

T_p temperature of the bare plate

t_1, t_2 time necessary to reach the levels 1 and 2

w mass fraction expressed as a percentage

w_w mass fraction of water absorbed

3.2.2 Subscripts

a ambient environment

f final

i initial

in intrinsic

p plate or bare plate

tot total

w water

4 Design and performance requirements — Approach A

4.1 General

This clause specifies test methods and minimum requirements for protective clothing to be worn during firefighting and associated activities where there is a risk of heat and/or flame.

It covers the general clothing design, the minimum performance levels of the materials used, and the methods of test for determining these performance levels. Performance levels in this clause are based on EN 469[1].

4.2 Design requirements

4.2.1 Configuration

The firefighters' protective clothing shall provide protection for the firefighter's upper and lower torso, neck, arms, and legs, but excluding the head, hands, and feet. It shall consist of:

a) a single outer garment; or

b) an outer two piece suit consisting of a jacket and a pair of trousers with a minimum overlap of 30 cm; or

c) a series of outer and undergarments designed to be worn together.

If choosing to comply with Approach A of this clause — which allows an area of limited protection — the following points shall be met:

a) the upper body shall be protected by clothing meeting requirements of Approach A of this clause;

b) the area of limited protection shall be in the lower body area;

c) the level of performance when tested in accordance with ISO 6942 at 40 kW/m^2 and ISO 9151 shall be declared.

4.2.2 Restriction of movement

The clothing shall be designed to minimize restrictions of movement. It shall be compatible with other protective equipment which may be necessary, for example boots, helmet, gloves and breathing apparatus.

4.2.3 Multilayer clothing assemblies

Where multilayer clothing assemblies are used to achieve the specified performance levels, the layers shall be either permanently attached or the various garments shall be clearly labelled that they must always be used in combination (see 4.2.6).

4.2.4 Seams

Seams shall be constructed to give the minimum loss in strength and protection and to maintain the integrity of the garment.

4.2.5 Hardware

Hardware penetrating the outer material shall not be exposed on the innermost surface of the component assembly.

4.2.6 Closure systems

Closure systems shall be constructed so as to fulfil the performance requirements of the garment.

4.2.7 Retroreflective elements

The clothing shall have retroreflective elements to the user's requirements provided that they do not affect the performance of the clothing.

4.2.8 Sleeve ends

The ends of the sleeves shall be designed to protect the wrist and to prevent the entry of burning debris. They shall not hinder the donning of the garment and shall be compatible with the wearing of protective gloves.

4.2.9 Clothing mass

The clothing shall be as light as possible while still maintaining the required performance levels.

4.2.10 Ease of cleaning

The clothing shall be designed to promote ease of cleaning.

4.2.11 Labels

Any labels or trim shall not adversely affect the performance of the garment.

4.3 Sampling and pretreatment

4.3.1 Samples

Samples shall be taken so as to be representative of the materials and garment construction employed.

4.3.2 Number and size of specimens

The number and size of specimens for the different tests shall be in accordance with the respective standards. All tests shall be carried out on materials as received unless otherwise specified (see 4.3.4).

4.3.3 Exposure surface

In all surface tests, the outermost surface shall be exposed, except for flame spread testing of the innermost lining (see 4.4.1) and testing of water vapour permeability (see 4.4.11) when the innermost surface is exposed.

4.3.4 Pretreatment

Before testing to the basic safety requirements (4.4.1, 4.4.2 and 4.4.3), the test materials shall be washed five times in a front loading horizontal drum machine with 1 g/l IEC reference detergent (annex B of ISO 6330:1984) in soft water and dried in accordance with the procedures of ISO 6330. Washing shall be carried out by procedure 2A at (60 ± 3) °C and drying by procedure E (tumble drying) unless otherwise specified in the care labelling. Drying shall be in accordance with the procedures of ISO 6330. A total of five washing and drying cycles shall be used. Materials which are labelled as dry cleanable only shall be dry cleaned five times in accordance with ISO 3175-2.

4.4 Requirements

4.4.1 Flame resistance (surface exposure)

Flame spread shall be tested in accordance with EN 532 after the pretreatment specified in 4.3.4 and the following requirements shall be satisfied.

a) No specimen shall give flaming to top or either side edge;

b) No specimen shall give hole formation in any layer, except the outer layer of a multilayer assembly;

c) No specimen shall give flaming or molten debris;

d) The mean value of afterflame time shall be ⩽ 2 s;

e) The mean value of the afterglow time shall be ⩽ 2 s.

The component assembly of the outer garment shall be tested by applying the flame to the outer surface of the garment.

If the outer garment has a lining material, the component assembly of the outer garment shall also be tested with the flame applied to the innermost lining of the outer garment.

If the clothing assembly consists of several separate garments and the undergarment may be exposed to flame, the component assembly of this undergarment shall also be tested applying the flame to the outer surface of this inner garment.

If the clothing assembly incorporates wristlet material, this shall be tested separately applying the flame to the outer surface of the wristlet material.

NOTE Hole formation is permitted in moisture barrier interlinings. The following clarification is offered for 4.4.1 b): "No specimen shall give hole formation in any layer, except for a layer which is used for specific protection other than heat protection, for example, liquid penetration, high visibility, etc."

4.4.2 Heat transfer (flame exposure)

The component assembly or multilayer clothing assembly when tested in accordance with ISO 9151 after the pretreatment specified in 4.3.4 shall give a mean heat transmission index (I_Q) of $I_{Q,24} \geqslant 13$ and a mean $(I_{Q,24} - I_{Q,12}) \geqslant 4$.

4.4.3 Heat transfer (radiant exposure)

The component assembly or multilayer clothing assembly when tested in accordance with method B of ISO 6942:1993 at a heat flux density of 40 kW/m^2, after the pretreatment specified in 4.3.4, shall give a mean $t_2 \geqslant 22$ s, a mean $(t_2 - t_1) \geqslant 6$ s, and a mean transmission factor $\leqslant 60$ %.

4.4.4 Residual strength of material when exposed to radiant heat

One machine and one cross machine specimen of the outer material shall be tested in accordance with ISO 5081 before and after pretreatment of the complete assembly by method A of ISO 6942:1993 at a heat flux density of 10 kW/m^2. Each specimen shall have a tensile strength $\geqslant 450$ N.

4.4.5 Heat resistance

Each material used in the clothing assembly when tested in accordance with the method given in annex A at a test temperature of 180 °C, shall not melt, drip, separate, or ignite, and shall not shrink more than 5 %.

4.4.6 Tensile strength

The outer material when tested in accordance with ISO 5081 shall give a breaking load in both machine and cross direction $\geqslant 450$ N.

4.4.7 Tear strength

The outer material when tested in accordance with method A2 of ISO 4674:1977 shall give a tear strength in both machine and cross direction $\geqslant 25$ N.

4.4.8 Surface wetting

The outer material when tested in accordance with ISO 4920 shall give a spray rating of $\geqslant 4$.

4.4.9 Cleaning-shrinkage resistance

The materials of the outer garment assembly when tested in accordance with ISO 5077 using the cleansing pretreatment specified in 4.3.4 shall give a dimensional change $\leqslant$ 3% in both the machine and cross machine directions.

4.4.10 Liquid-chemical penetration resistance

The component assembly or multilayer clothing assembly when tested in accordance with ISO 6530 using:

a) 40 % sodium hydroxide (NaOH) at 20 °C;

b) 36 % hydrochloric acid (HCl) at 20 °C;

c) 30 % sulfuric acid (H_2SO_4) at 20 °C;

d) white spirit;

shall give > 80 % run-off and no penetration to the innermost surface.

NOTE Fabrics shall be conditioned for 24 h at (20 ± 2) °C and (65 ± 5) % RH before testing. All tests shall be carried out with a pouring time of 10 s and at a temperature of 20 °C.

4.4.11 Water-penetration resistance and water-vapour resistance

It is recommended that the manufacturer should supply information on the behaviour of the clothing assembly when tested according to ISO 811 for hydrostatic pressure and to ISO 11092[2] for water-vapour resistance.

4.5 Additional garment testing

If agreed between the purchaser and the manufacturer, the complete garment assembly may be additionally tested to typical scenarios encountered by a firefighter (see Table 1).

Table 1 — Additional testing

Conditions	Exposure time	Temperature	Heat flux density
Normal	8 h	40 °C	1 kW/m^2
Hazardous	5 min	250 °C	1,75 kW/m^2
Emergency	10 s	800 °C	40 kW/m^2

Testing under emergency conditions must be carried out on an equipped mannequin and may involve shorter exposure at higher temperature and heat flux levels. The test will be followed by a visual inspection.

4.6 Marking

Firefighter protective clothing, for which compliance with this International Standard is claimed, shall have a label permanently and conspicuously attached marked with the number of this International Standard, i.e. ISO 11613, clause 4.

If the requirements are only met by the use of a combination of garments [see 4.2.1 c)] this must be declared on the labels of all the garments involved.

General marking requirements shall be as specified in ISO 13688.

4.7 Manufacturers' information

The manufacturer's information shall be given as specified in ISO 13688.

5 Design and performance requirements — Approach B

5.1 General

This clause specifies test methods and minimum requirements for protective clothing to be worn during firefighting and associated activities where there is a risk of heat and/or flame.

It covers the general clothing design, the minimum performance levels of the materials used, and the methods of test for determining these performance levels. Performance levels in this clause are based on NFPA 1971[3].

5.2 Design requirements

5.2.1 Composite

Protective garments shall consist of a composite of an outer shell, moisture barrier, and thermal barrier. This composite shall be permitted to be configured as a single layer or multiple layers.

NOTE Purchasers might wish to specify additional reinforcement or padding in high-wear or load-bearing areas, such as pockets, cuffs, knees, elbows, and shoulders. Padding can include additional thermal barrier material meeting requirements as specified herein. Reinforcing material can include outer-shell material or leather. Purchasers are cautioned that additional weight caused by excessive reinforcement or padding could lead to fatigue or result in injury.

The thermal barrier or portion of the thermal barrier shall be permitted to be configured as a protective-uniform garment. When configured in this manner, the assembled protective garment shall meet all requirements specified in this International Standard.

5.2.2 Attachment of moisture barrier and thermal barrier

Protective garments shall have a means of securing the moisture barrier and thermal barrier to the outer shell.

NOTE The fastener system should be specified by the purchaser. Fastener system methods can include (but are not limited to) stitching the thermal barrier and moisture barrier into the coat in the neck, or into the trouser in the waist area with snap or hook and pile fasteners securing the remainder; entirely stitching the thermal barrier and moisture barrier to the outer shell; entirely securing the thermal barrier and moisture barrier to a component part of the outer shell with snap fasteners or fastener tape; or zipping the thermal barrier and vapour barrier to the outer shell.

5.2.3 Use of fasteners

Protective garments, including the front closure, shall be constructed in a manner that provides secure and complete moisture and thermal protection. If non-positive fasteners, such as snaps or hook and pile tape, are utilized in garment closures, a positive locking fastener, such as hooks and dees or zippers, shall also be utilized.

5.2.4 Extension of moisture and thermal barriers

The distance from the outer-shell cuffs and hems to the moisture and thermal barriers shall not exceed 76 mm. At the neck, the coat moisture barrier and thermal barrier shall extend to the neckline seam. The upper edge of the trouser moisture barrier and thermal barrier shall extend, as a minimum, to the waistline.

5.2.5 Cargo pocket requirements

Cargo pockets, where provided, shall have a means of drainage of water and shall have a means of fastening them in the closed position.

NOTE Purchasers should specify pockets large enough to carry tools and items normally carried. Placement should allow for access to the pockets while wearing SCBA. Specifying ballooned pockets will increase capacity but could interfere with manoeuvrability. Ballooning only the back edges could minimize the manoeuvrability problem. Divided pockets could be desired, as well as pockets for specific items, such as SCBA facepieces and radios.

5.2.6 Trim dimensions and coverage

Trim utilized to meet visibility requirements shall be permanently attached to the outer shell of protective garments and shall be no less than 50 mm wide and shall have both retroreflective and fluorescent surfaces. Retroreflective surface of trim shall be no less than 16 mm wide. Fluorescent and retroreflective areas of trim shall appear to be continuous for the length of the trim, with gaps between areas of retroreflectivity of no more than 4 mm.

NOTE Users of protective clothing should be aware that retroreflective trims have varying durability under field use conditions. Trim may be damaged by heat but appear to be in good condition when in fact it may have lost retroreflective properties. Trim may become soiled and lose fluorescing and retroreflective qualities. Trim may lose retroreflective qualities in rain or firefighting water exposures.

5.2.7 Excess trim

Trim affixed to protective garments exceeding the visibility requirements specified in 5.4.8 of this International Standard shall be permitted to be obscured by components such as, but not limited to, pockets, storm flaps, and reinforcing patches as long as the minimum trim required in 5.2.8. and 5.2.9 is not obscured.

NOTE Purchasers of protective clothing should realize that trim patterns can materially affect the visibility of the firefighter. Trim patterns should be evaluated on live models as the models proceed through a series of arm and leg motions, bending, stooping, and turning.

5.2.8 Additional requirements for protective coats

5.2.8.1 Area of protection

Protective coats shall provide protection as specified to the upper torso, neck, arms, and wrists, excluding the hands and head.

NOTE A protective ensemble consisting of both protective coat and protective trousers is required to be utilized for structural firefighting in order to assure better protection for the firefighter's torso and limbs by 5-2.6 of NFPA 1500[4]. An overlap of no less than 203 mm of coat and trousers is also required by 5-2.1 of NFPA 1500 and should be specified to assure better protection.

5.2.8.2 Hardware

Protective coat hardware shall not penetrate through the outer shell, moisture barrier, and thermal barrier to contact the wearer's body when the coat is worn with closures fastened, unless the hardware is completely covered by external closure flaps.

5.2.8.3 Protective wristlets

Each protective coat sleeve shall have a protective wristlet meeting requirements specified in 5.2.12 and 5.6 of this International Standard.

NOTE Purchasers should consider specifying wristlets with a thumb hole or bartack creating a thumb hole for wearer's thumb in order to assure protection when arms are in raised position.

5.2.8.4 Composite collar

Protective coats shall have a composite collar no less than 102 mm in height at any point, with a closure system. Collar and closure system shall consist of outer shell, moisture barrier, and thermal barrier that meet all applicable performance requirements as specified in 5.2.

5.2.8.5 Trim location

Protective coat trim configuration shall include a circumferential band around the coat and each wrist. No vertical trim shall be allowed on the front of the protective coat.

NOTE A possible configuration for trim on coats or coveralls, in addition to the minimum requirements specified herein, is two 635 mm vertical stripes on the coat back intersecting the circumferential stripe (forming a “U”). Use of vertical trim on protective garment fronts has been shown to be capable of detrimentally affecting the performance of SCBA in flashover heat/flame conditions.

5.2.8.6 Trim minimum area

Protective coat trim shall have no less than 2 100 cm^2 of fluorescent area.

5.2.8.7 Visible trim minimum areas

Protective coat trim shall include no less than 1 050 cm^2 of fluorescent area visible from the front and 1 050 cm^2 of fluorescent area visible from the rear when the coat is properly closed and is laid on a flat inspection surface.

5.2.9 Additional requirements for protective trousers

5.2.9.1 Area of protection

Protective trousers shall provide protection as specified to the lower torso and legs, excluding the ankles and feet.

NOTE A protective ensemble consisting of both protective coat and protective trousers is required to be utilized for structural firefighting in order to assure better protection for the firefighter’s torso and limbs in accordance with 5-2.6 of NFPA 1500. An overlap of no less than 203 mm of coat and trousers is also required by 5-2.1 of NFPA 1500 and should be specified to assure adequate protection.

5.2.9.2 Hardware

Protective trouser hardware shall not penetrate through the outer shell, moisture barrier, and thermal barrier to contact the wearer’s body when trouser is worn with closure fastened, unless the hardware is located on or above the waistline or hardware is completely covered by external closure flaps.

5.2.9.3 Trim location

Protective trouser trim shall include a circumferential band around each leg between the hem and knee.

5.2.9.4 Trim minimum area

Protective trouser trim shall have no less than 520 cm^2 of fluorescent area.

5.2.9.5 Visible trim minimum areas

Protective trouser trim shall include no less than 260 cm^2 of fluorescent area visible from the front and no less than 260 cm^2 of fluorescent area visible from the rear when the trouser is properly closed and is laid on a flat inspection surface.

5.2.10 Additional requirements for protective coverall

That portion of the protective coverall that corresponds to the protective coat shall meet all requirements of 5.2.8.

That portion of the protective coverall that corresponds to the protective trouser shall meet all requirements of 5.2.9.

5.2.11 Specific requirements for protective hoods

The protective hood shall be designed to cover and provide the limited protection specified in 5.5 to the head, face, and neck, which are not protected by the protective coat, helmet, or SCBA facepiece.

The protective hood shall be designed to contact the sides of the SCBA facepiece, when worn, to cover all exposed facial areas. The protective hood shall be designed so that it does not interfere with the proper use of SCBA and the SCBA facepiece-to-face seal, as specified by the SCBA manufacturer.

The protective hood shall be designed so that it does not interfere with the proper use and fit of helmets, as specified by the helmet manufacturer.

5.2.12 Specific requirements for protective wristlets

The protective wristlet shall be designed to cover and provide the limited protection specified within this subclause to the wrist areas.

The protective wristlet shall be permanently attached to the protective coat.

5.3 Sampling and pretreatment

5.3.1 Sampling levels

Sampling levels for testing and inspection shall be established by the responsible testing laboratory and the manufacturer to assure a reasonable and acceptable reliability at a reasonable and acceptable confidence level that products certified as being compliant with this International Standard are compliant.

5.3.2 Inspection

Inspection for determining compliance with the design requirements specified in 5.2 shall be performed on a completed garment.

5.3.3 Testing

Testing for determining material and component compliance with the requirements specified in 5.4 shall be performed on samples representative of materials and components used in the actual construction of the protective clothing. The responsible testing laboratory organization shall be permitted to also use sample materials cut from a representative protective garment.

5.3.4 Pretreatment

When pretreatment is specified as part of the test procedure or performance requirement, the test materials shall be washed five times in a front loading horizontal drum machine with 1 g/l IEC reference detergent (annex B of ISO 6330:1984) in soft water and dried in accordance with the procedures of ISO 6330. Washing shall be carried out by procedure 2A at (60 ± 3) °C and drying by procedure E (tumble drying) unless otherwise specified in the care labelling. Drying shall be in accordance with the procedures of ISO 6330. A total of five washing and drying cycles shall be used. A laundry bag shall not be used.

5.4 Performance requirements

5.4.1 Protective garment requirements

5.4.1.1 Heat transfer (combined radiant and flame exposure)

The protective garment composite consisting of outer shell, moisture barrier, and thermal barrier shall have a heat transfer burn time of no less than 17,5 s when tested for heat transfer (combined radiant and flame exposure) in accordance with ISO 17492, using the thermal protection index (I_T) analysis method with the specimens in the contact configuration, before and after the pretreatment specified in 5.3.4.

5.4.1.2 Seam strength

All seams shall be tested for breaking strength and shall demonstrate a seam strength equal to or greater than 675 N force for major A seams, 337 N force for major B seams, and 180 N force for minor seams when tested as specified in ISO 5082, with the test machine operated at a rate of 305 mm/min. Seam breaking strength shall be considered acceptable when the fabric strength is less than the required seam strength specified above, providing the fabric fails without failure of the seam below the applicable forces specified above.

5.4.1.3 Breathability

It is recommended that the manufacturer supply information on the behaviour of the composite when tested in accordance with ISO 11092 as modified by annex B for total heat loss.

5.4.2 Textiles

5.4.2.1 Flame resistance (edge exposure)

Outer shell, moisture barrier, thermal barrier, collar linings, winter liner fabric, and trim shall be individually tested for flame resistance and shall have an average char length of no more than 102 mm, an average afterflame of no more than 2 s, and shall not melt or drip when tested in accordance with ISO 15025 as modified by annex D, before and after the pretreatment specified in 5.3.4.

5.4.2.2 Thermal-shrinkage resistance

Outer shell, moisture barrier, thermal barrier, collar linings, and winter liner fabric shall be individually tested for thermal-shrinkage resistance and shall not shrink more than 10 % in any direction when tested in accordance with ISO 17493, using the procedure for flat textile and other sheet materials at a test temperature of 260 °C, before and after the pretreatment specified in 5.3.4.

5.4.2.3 Heat resistance

Outer shell, moisture barrier, thermal barrier, collar linings, and winter liner fabric, and other materials used in construction — including but not limited to padding, reinforcement, garment labels, interfacing, binding, hanger loops, and emblems, but excluding trim, elastic and hook and pile fasteners when not placed in direct contact with the body — shall be individually tested for heat resistance and shall not melt, separate, or ignite when tested in accordance with ISO 17493, using the procedure for flat textile and other sheet materials at a test temperature of 260 °C, before and after the pretreatment specified in 5.3.4.

Moisture barrier seam seal materials shall be tested for heat resistance and shall not drip or ignite when tested in accordance with the method given in ISO 17493 when tested at a temperature of 260 °C.

5.4.2.4 Cleaning-shrinkage resistance

Outer shell, moisture barrier, thermal barrier, collar linings, and winter liner fabric shall be individually tested for cleaning-shrinkage resistance in accordance with ISO 5077 using the cleansing pretreatment specified in 5.3.4 and shall not shrink more than 5 % in any direction. Knit fabric specimens shall be pulled to original dimensions and shall be allowed to relax for 1 min prior to measurement.

5.4.3 Outer shell requirements

5.4.3.1 Tear resistance

Outer-shell and collar-lining fabrics shall be tested for tear resistance and shall have a tear strength of no less than 100 N when tested as specified in accordance with ISO 9073-4.

5.4.3.2 Char resistance

Outer-shell and collar-lining fabrics shall be tested for char resistance and shall not char when tested in accordance with the method given in ISO 17493 when tested at a temperature of 260 °C, before and after the pretreatment specified in 5.3.4.

5.4.3.3 Water-absorption resistance

Outer-shell and collar-lining fabrics shall be tested for water-absorption resistance and shall have no more than 30 % water absorption when tested in accordance with ISO 4920 as modified by annex E, before and after the pretreatment specified in 5.3.4.

5.4.4 Moisture barrier requirements

5.4.4.1 Tear resistance

Moisture barriers shall be tested for tear resistance and shall have a tear strength of no less than 22 N when tested in accordance with ISO 9073-4.

5.4.4.2 Water-penetration resistance (high pressure)

The moisture barrier fabric shall be tested for high pressure range water-penetration resistance and shall have a minimum water-penetration resistance of 172 kPa when tested in accordance with ISO 811 using a rate of water pressure increase of 60 cm/min, before and after the pretreatment specified in 5.3.4. Appearance of water drops shall constitute failure.

5.4.4.3 Water-penetration resistance (low pressure)

The moisture barrier fabric and seams shall be tested for low pressure range water-penetration resistance and shall show no appearance of water drops when tested in accordance with ISO 811 at 7 kPa for a period of 5 min, before and after the pretreatment specified in 5.3.4.

5.4.5 Thermal barrier requirement

Thermal barrier shall be tested for tear resistance and shall have a tear strength of no less than 22 N when tested in accordance with ISO 9073-4.

5.4.6 Winter liner requirement

When provided, the winter liner shall be tested for tear resistance and shall have a tear strength of no less than 22 N when tested in accordance with ISO 9073-4.

5.4.7 Thread requirement

All thread utilized in the construction of the protective garments shall be tested for heat resistance and shall not ignite, melt, or char when tested in accordance with ISO 3146 when tested at a temperature of 260 °C.

5.4.8 Visibility requirements for trim

Protective coat-trim shall have a total coefficient of luminous intensity (C_l) of no less than 25 cd/lx (270 cd/foot-candle) when tested in accordance with ASTM E 809 and the test parameters given in annex C.

Protective trouser-trim shall have a total coefficient of luminous intensity (C_l) of no less than 7 cd/lx (75 cd/foot-candle) when tested in accordance with ASTM E 809 and the test parameters given in annex C.

5.4.9 Hardware requirements

5.4.9.1 Surface finish

All hardware finish shall be free of rough spots, burrs, or sharp edges.

5.4.9.2 Corrosion resistance

All metal hardware and hardware that includes metal parts shall be tested for corrosion resistance when tested in accordance with ISO 9227 using a 5 % saline solution and 20 h test exposure followed by immediately rinsing the specimens under warm, running tap water and drying with compressed air. Metals inherently resistant to corrosion, including but not limited to stainless steel, brass, copper, aluminium, and zinc shall show no more than light surface-type corrosion or oxidation. Ferrous metals shall show no corrosion of the base metal.

5.4.9.3 Heat resistance

All hardware shall be tested for heat resistance and shall not ignite and shall remain functional when tested in accordance with the method given in annex A when tested at a temperature of 260 °C.

5.5 Protective hood requirements

5.5.1 Heat transfer (combined radiant and flame exposure)

The protective hood fabric or component assembly shall have a heat transfer burn time of no less than 10 s when tested for heat transfer (combined radiant and flame exposure) in accordance with ISO 17492, using thermal protection index (I_T) analysis method with the specimens in the contact configuration, before and after the pretreatment specified in 5.3.4.

5.5.2 Flame resistance (edge exposure)

The protective hood material(s), including labels, but excluding hook and pile fasteners and elastic when not placed in direct contact with the body, shall be individually tested for flame resistance and shall have an average char length of no more than 102 mm, an average afterflame of no more than 2 s, and shall not melt or drip when tested in accordance with ISO 15025 as modified by annex D, before and after the pretreatment specified in 5.3.4.

5.5.3 Thermal-shrinkage resistance

The protective hood material(s), including labels, but excluding hook and pile fasteners and elastic when not placed in direct contact with the body, shall be individually tested for thermal-shrinkage resistance and shall not shrink more than 10 % in any direction when tested in accordance with ISO 17493, using the procedure for flat textile and other sheet materials at a test temperature of 260 °C, before and after the pretreatment specified in 5.3.4.

5.5.4 Heat resistance

The protective hood material(s), including labels, but excluding hook and pile fasteners and elastic when not placed in direct contact with the body, shall be individually tested for heat resistance and shall not melt, separate, or ignite when tested in accordance with ISO 17493, using the procedure for flat textile and other sheet materials at a test temperature of 260 °C, before and after the pretreatment specified in 5.3.4.

5.5.5 Cleaning-shrinkage resistance

The protective hood material(s), including labels, but excluding hook and pile fasteners and elastic when not placed in direct contact with the body, shall be individually tested for cleaning-shrinkage resistance in accordance with ISO 5077 using the cleansing pretreatment specified in 5.3.4 and shall not shrink more than 5 % in any direction. Knit fabric specimens shall be pulled to original dimensions and shall be allowed to relax for 1 min prior to measurement.

5.5.6 Thread heat resistance

All thread utilized in the construction of the protective hood shall be tested for heat resistance and shall not ignite, melt, or char when tested in accordance with ISO 3146.

5.6 Protective wristlet requirements

5.6.1 Heat transfer (combined radiant and flame exposure)

The protective wristlet shall have a heat transfer burn time of no less than 10 s when tested for heat transfer (combined radiant and flame exposure) in accordance with ISO 17492, using thermal protection index (I_T) analysis method with the specimens in the contact configuration, before and after the pretreatment specified in 5.3.4.

5.6.2 Flame resistance (edge exposure)

The protective wristlet material(s) shall be individually tested for flame resistance and shall have an average char length of no more than 102 mm, an average afterflame of no more than 2 s, and shall not melt or drip when tested in accordance with ISO 15025 as modified by annex D, before and after pretreatment specified in 5.3.4.

5.6.3 Thermal-shrinkage resistance

The protective wristlet material(s) shall be individually tested for thermal-shrinkage resistance and shall not shrink more than 10 % in any direction when tested in accordance with ISO 17493, using the procedure for flat textile and other sheet materials at a test temperature of 260 °C, before and after the pretreatment specified in 5.3.4.

5.6.4 Heat resistance

The protective wristlet material(s) shall be individually tested for heat resistance and shall not melt, separate, or ignite when tested in accordance with ISO 17493, using the procedure for flat textile and other sheet materials at a test temperature of 260 °C, before and after the pretreatment specified in 5.3.4.

5.6.5 Cleaning-shrinkage resistance

The protective wristlet material(s) shall be individually tested for cleaning-shrinkage resistance in accordance with ISO 5077 using the cleansing pretreatment specified in 5.3.4 and shall not shrink more than 5 % in any direction. Knit fabric specimens shall be pulled to original dimensions and shall be allowed to relax for 1 min prior to measurement.

5.6.6 Thread heat resistance

All thread utilized in the construction of the protective wristlet shall be tested for heat resistance and shall not ignite, melt, or char when tested in accordance with ISO 3146.

5.7 Marking

5.7.1 Label

Each separable layer of each protective garment shall have a label permanently and conspicuously attached to each layer upon which at least the information given in Figure 1 is printed in letters at least 1,5 mm high. At least one label shall be conspicuously located inside the garment in all possible configurations of garment utilization.

“THIS STRUCTURAL FIREFIGHTING PROTECTIVE GARMENT MEETS THE REQUIREMENTS OF ISO 11613, CLAUSE 5”

Manufacturer’s name

Manufacturer’s address

Country of manufacture

Manufacturer’s garment identification number

Date of manufacture

Size

Cleaning and drying instructions

Garment material(s)

“DO NOT REMOVE THIS LABEL”

Figure 1 — Label

5.7.2 Label legibility

All garment labels shall be clearly legible to the eye both before and after being subjected to the pretreatment specified in 5.3.4. Garment labels not meeting specimen size requirements for the procedure specified in 5.3.4 shall be sewn to a support fabric of required size.

5.8 Manufacturers’ information

5.8.1 Instructions and information

Protective-clothing manufacturers shall provide the following instructions and information with each garment:

a) cleaning and instructions;

b) maintenance criteria;

c) methods of repair;

d) warranty information.

5.8.2 Training materials

Protective-clothing manufacturers shall furnish training materials that address, but are not limited to:

a) safety considerations;

b) storage conditions;

c) decontamination procedures;

d) retirement considerations.

Annex A
(normative)

Heat resistance test

A.1 Principle

Specimens of the material shall be suspended in a hot air circulating oven for 5 min at the specified test temperature. Any ignition, melting, dripping, separation or shrinking of the specimen shall be recorded.

A.2 Apparatus

A.2.1 Forced-air circulating oven, capable of maintaining the test temperature over a period of 5 min and of sufficient internal volume to allow the test specimen (see A.3) to be suspended as specified in A.4.

A.2.2 Rigid-square template, 150 mm by 150 mm.

A.2.3 Ruler, graduated in millimetres.

A.3 Specimens

Condition the material for at least 24 h in a standard atmosphere at (20 ± 2) °C and (65 ± 5) % RH. Mark and cut out a square specimen using the template (A.2.2). If the material or item for test is narrower than 150 mm, cut the specimen 150 mm in the length direction by the width of the material. If the item for test is less than 150 mm by 150 mm, test the complete item.

A.4 Procedure

Attach a metal clip to the top centre of the specimen. Heat the oven to the test temperature. Open the oven door and quickly insert the specimen so that it hangs in the centre of the oven and is no less than 50 mm from any inner surface of the oven. Close the door and time the exposure from the door closure. After 5 min, open the oven door and remove the specimen.

The oven temperature will drop when the door is opened. The temperature throughout the 5 min exposure period should remain above the test temperature. If the temperature falls below this level, repeat the test.

A.5 Report

The report shall include the following observations:

a) any ignition of the specimen;

b) any melting of the specimen: hole formation, dripping;

c) any separation of the specimen: splitting, delamination;

d) any shrinkage of the specimen in either length or width direction, if the shrinkage is greater than 5 % and the specimen was originally 150 mm in that direction.

Annex B
(normative)

Total heat-loss test

B.1 Principle

This test method involves the measurement of evaporative heat transfer through the component assembly using a hot plate. The thermal resistance of the component assembly is first measured using a hot plate with the capacity for measuring heat loss through the multiple layers. The evaporative resistance is then measured using the same hot plate with water added to simulate sweating. The thermal resistance and evaporative resistance are then used to calculate total heat loss.

NOTE This is a unique test for firefighter protective clothing which has been taken from NFPA 1971. It differs from ISO 11092 by conducting the evaluation under non-isothermal conditions.

B.2 Apparatus

The test apparatus shall consist of a test plate with temperature controller and power-input measuring capability. The test plate shall be surrounded by a guard ring and bottom plate that can be controlled to eliminate lateral and downward heat transfer from the test plate. The test plate and guard ring shall have a wettable surface. The test plate, guard ring, and bottom plate shall be in an environmental chamber that can control the temperature, relative humidity, and air flow over the test plate. These properties shall be continuously measured in the free flow air stream uninfluenced by the boundary of the test plate. Apparatus used to measure temperature shall be accurate to within ± 0,25 °C. Apparatus used to measure relative humidity shall be accurate to within ± 4 % RH.

B.3 Specimens

Total heat-loss testing shall be conducted on at least three specimens. Specimens shall consist of all layers in the protective garment component assembly arranged in the order and orientation as worn.

B.4 Procedure

B.4.1 The test plate shall have a temperature of (35 ± 0,5) °C.

B.4.2 The local environmental climate shall be (25 ± 0,5) °C and (65 ± 4) % RH.

B.4.3 The air flow shall be the same for all calibrations and tests.

B.4.4 The total thermal resistance ($R_{T,\mathrm{tot}}$) of the specimen shall be calculated from the following equation:

$$R_{T,\mathrm{tot}} = \frac{\left(T_\mathrm{p} - T_\mathrm{a}\right) \times A_\mathrm{p}}{H}$$

where:

$R_{T,\mathrm{tot}}$ is the total thermal resistance of the specimen and surface air layer (°C m²/W);

T_p is the temperature at the plate surface (°C);

T_a is the temperature in the ambient environment (°C);

A_p is the area of the test plate (m^2);

H is the power input (W).

B.4.5 Measurement of thermal resistance shall be done when equilibrium is reached.

B.4.5.1 Data used to calculate the thermal resistance shall be collected at least every 5 min.

B.4.5.2 Equilibrium shall be a rate of change of less than 3 %/h of the calculated thermal resistance over a period no less than 30 min.

B.4.5.3 The standard deviation of calculated thermal resistance shall be less than 1 %.

B.4.6 The average bare plate thermal resistance, including the air layer and any apparatus contribution ($R_{T,\text{p}}$) shall be an average of at least three measurements with nothing mounted on the test plate.

B.4.7 The average intrinsic thermal resistance of the sample alone ($R_{T,\text{in}}$) shall be determined by subtracting the average bare plate resistance ($R_{T,\text{p}}$) from the average of the total thermal resistance ($R_{T,\text{tot}}$) of the specimens tested.

B.4.8 For thermal resistance measurements, the apparatus shall be calibrated as follows:

B.4.8.1 One layer of 255 g/m^2 Nomex duck shall be mounted on the test plate and the total thermal resistance ($R_{T,\text{tot}}$) shall be measured.

B.4.8.2 Two layers of 255 g/m^2 Nomex duck shall be mounted on the test plate and the total thermal resistance ($R_{T,\text{tot}}$) shall be measured.

B.4.8.3 Three layers of 255 g/m^2 Nomex duck shall be mounted on the test plate and the total thermal resistance ($R_{T,\text{tot}}$) shall be measured.

B.4.8.4 Four layers of 255 g/m^2 Nomex duck shall be mounted on the test plate and the total thermal resistance ($R_{T,\text{tot}}$) shall be measured.

B.4.8.5 The apparatus shall meet the following constraints:

a) a graph of total thermal resistance versus number of layers of 255 g/m^2 Nomex duck shall be linear for the bare plate value, one, two, three, and four layers;

b) the slope of the linear regression shall be $0{,}0206 \times (1 \pm 10\ \%)$ °C·m^2/W;

c) no individual data measurement shall be outside ±10 % of the value predicted by the linear regression;

d) the intrinsic thermal resistance of four layers of 255 g/m^2 Nomex duck shall be $0{,}082 \times (1 \pm 10\ \%)$ °C·m^2/W.

B.4.8.6 If the apparatus cannot meet any one of these constraints, no specimens shall be tested until the apparatus is adjusted to meet these constraints.

B.4.9 The specimen to be tested shall be mounted on the test plate in the orientation it has in the finished garment from the skin surface (plate surface) to the outside and the total thermal resistance ($R_{T,\text{tot}}$) shall be measured.

B.4.10 Water shall be fed to the test plate and guard ring so that water uniformly wets the test plate and guard ring surface.

B.4.11 The test plate and guard ring shall be covered with a liquid barrier that prevents wetting of the test specimen by the liquid water.

B.4.12 Apparent total evaporative resistance ($R_{e,tot}$) shall be calculated from the following equation:

$$R_{e,tot} = \frac{(p_p - p_a) \times A_p}{H - \dfrac{(T_p - T_a) \times A_p}{R_{T,tot}}}$$

where:

$R_{e,tot}$ is the apparent total evaporative resistance of the specimen and air layer (kPa m^2/W);

p_p is the water vapour pressure at the test plate surface (kPa);

p_a is the water vapour pressure in the ambient environment (kPa);

A_p is the area of the test plate (m^2);

H is the power input (W);

T_p is the temperature at the test plate surface (°C);

T_a is the temperature in the ambient environment (°C);

$R_{T,tot}$ is the total thermal resistance of the specimen and surface air layer (°C · m^2/W).

NOTE The term “apparent” is used as a modifier for evaporative resistance to reflect the fact that condensation may occur within the specimen.

B.4.13 Measurement of apparent evaporative resistance shall be done when equilibrium is reached.

B.4.13.1 Data to calculate apparent evaporative resistance shall be collected at least every 5 min.

B.4.13.2 Equilibrium shall be a rate of change of less than 3 %/h of calculated apparent evaporative resistance over a period no less than 30 min.

B.4.13.3 The standard deviation of the calculated apparent evaporative resistance shall be less than 1 %.

B.4.13.4 If data collection cannot be completed within 4 h after mounting the specimen on the test plate, the specimen shall be removed from the test plate and allowed to dry at least 24 h at (20 ± 5) °C before retesting. Subsequent data reporting shall state that drying was required. If the retest of the specimen still cannot be completed within 4 h, then it shall be reported that the specimen cannot be tested by this method.

B.4.14 The average bare plate evaporative resistance, including the air layer, the liquid barrier, and any apparatus contribution, ($R_{e,p}$) shall be an average of at least three measurements with only the liquid barrier mounted on the plate. The local environmental climate shall be permitted to increase above 25 °C if necessary to maintain test plate temperature at 35 °C.

B.4.15 The average apparent intrinsic evaporative resistance of the sample alone ($R_{e,in}$) shall be the apparent total evaporative resistance ($R_{e,tot}$) minus the average bare plate evaporative resistance ($R_{e,p}$).

$$R_{e,in} = R_{e,tot} - R_{e,p}$$

NOTE The term “apparent” is used as a modifier for evaporative resistance to reflect the fact that condensation may occur within the specimen.

B.4.16 For evaporative resistance measurements, the apparatus shall be recalibrated as follows:

B.4.16.1 The permeability index of the liquid barrier alone on the wetted test plate shall be greater than 0,7. The permeability index shall be calculated from the following equation:

$$I_{\text{m}} = 0{,}061 \times \frac{R_{T,\text{p}}}{R_{\text{e,p}}}$$

where:

I_{m} is the permeability index;

$R_{T,\text{p}}$ is the average bare plate thermal resistance (without liquid barrier) described in B.4.6 (°C·m²/W);

$R_{\text{e,p}}$ is the average bare plate evaporative resistance (with liquid barrier in place) described in B.4.14 (kPa·m²/W).

NOTE One material that will meet this requirement is uncoated cellophane from Flexel, Inc., Atlanta, GA 30346, USA.

B.4.16.2 One layer of 255 g/m² Nomex duck shall be mounted on the test plate and the apparent evaporative resistance ($R_{\text{e,tot}}$) shall be measured.

B.4.16.3 Two layers of 255 g/m² Nomex duck shall be mounted on the test plate and the apparent evaporative resistance ($R_{\text{e,tot}}$) shall be measured.

B.4.16.4 Three layers of 255 g/m² Nomex duck shall be mounted on the test plate and the apparent evaporative resistance ($R_{\text{e,tot}}$) shall be measured.

B.4.16.5 Four layers of 255 g/m² Nomex duck shall be mounted on the test plate and the apparent evaporative resistance ($R_{\text{e,tot}}$) shall be measured.

B.4.16.6 The apparatus shall meet the following constraints:

a) a graph of apparent total evaporative resistance ($R_{\text{e,tot}}$) versus number of layers of 255 g/m² Nomex duck shall be linear for the bare plate value, one, two, three, and four layers;

b) the slope of the linear regression shall be 0,005 × (1 ± 10 %) kPa·m²/W;

c) no individual data measurement shall be outside ± 10 % of the value predicted by the linear regression;

d) The apparent intrinsic evaporative resistance ($R_{\text{e,in}}$) of four layers of 255 g/m² Nomex duck shall be 0,020 × (1 ± 10 %) kPa·m²/W.

B.4.16.7 If the apparatus cannot meet any one of these constraints, no specimens shall be tested until the apparatus is adjusted to meet these constraints.

B.4.17 The specimen to be tested shall be mounted on the wetted test plate with the liquid barrier in place in the orientation it has in the finished garment from the skin surface (plate surface) to the outside.

B.5 Report

B.5.1 The average intrinsic thermal resistance ($R_{T,\text{in}}$) of the sample shall be reported. The average intrinsic thermal resistance ($R_{T,\text{in}}$) of the specimens shall be determined by averaging all values obtained over the equilibrium period (minimum of six). The average intrinsic thermal resistance ($R_{T,\text{in}}$) of the sample shall be determined by averaging the values for all specimens. If the results for any of the three individual specimens vary more than 10 % from the average of all three, then the test shall be repeated on the specimen(s) lying outside the ± 10 % limit. If the retest produces a value(s) within the ± 10 % limit, then the new value(s) shall be used instead. If the retest remains outside the ± 10 % limit, then an additional three specimens shall be tested, and all original and retest results shall be reported along with the average and standard deviation of intrinsic thermal resistance and a statement identifying this sample as having a high variability.

B.5.2 The average apparent intrinsic evaporative resistance ($R_{\mathrm{e,in}}$) of the sample shall be reported. The average apparent intrinsic evaporative resistance ($R_{\mathrm{e,in}}$) of the specimens shall be determined by averaging all values obtained over the equilibrium period (minimum of six). The average apparent intrinsic evaporative resistance ($R_{\mathrm{e,in}}$) of the sample shall be determined by averaging the values for all specimens. If the results for any of the three individual specimens vary more than 10 % from the average of all three, then the test shall be repeated on the specimen(s) lying outside the ± 10 % limit. If the retest produces a value(s) within the ± 10 % limit, then the new value(s) shall be used instead. If the retest remains outside the ± 10 % limit, then an additional three specimens shall be tested, and all original and retest results shall be reported along with the average and standard deviation of apparent intrinsic evaporative resistance and a statement identifying this sample as having a high variability.

B.5.3 The average total heat loss (Q_{tot}) of the sample shall be determined and reported, subject to the reporting requirements in B.5.1. and B.5.2. The total heat loss of the sample shall be calculated from the following equation:

$$Q_{\mathrm{tot}} = \frac{T_1}{R_{T,\mathrm{in}} + 0{,}04} + \frac{p_1}{R_{\mathrm{e,in}} + 0{,}0035}$$

where:

Q_{tot} is the total heat loss (W/m^2);

T_1 is the temperature equal to 10 °C;

p_1 is the pressure equal to 3,57 kPa;

$R_{T,\mathrm{in}}$ is the average intrinsic thermal resistance of the sample determined in B.5.1 (°C·m^2/W);

$R_{\mathrm{e,in}}$ is the average apparent intrinsic evaporative resistance of the sample determined in B.5.2 (kPa·m^2/W).

Annex C
(normative)

Retroreflective photometric performance test parameters

C.1 Test parameters

Test distance:	15,2 m
Observation angle:	0,2°
Entrance angle:	−4,0°
Photoreceptor angular aperture and source angular aperture:	0,1°
Projector exit aperture:	circle with 25 mm diameter
Retroreflector reference angle:	90°
Datum mark:	as specified by trim manufacturer
Trim specimen size:	305 mm × 305 mm made from multiple strips of trim

C.2 Calculation

The coefficient of luminous intensity for trim shall be calculated by the following equation where the coefficient of reflectivity, C_r, is measured in accordance with the above:

$$C_l = C_\mathrm{r} \times A_\mathrm{r}$$

where

C_l is the coefficient of luminous intensity expressed as cd/lx;

C_r is the coefficient of reflectivity expressed as cd/(lx · m^2);

A_r is the total retroreflective trim area expressed as m^2.

Annex D
(normative)

Measurement of char length — Procedure

D.1 Flame resistance

Outer shell, moisture barrier, thermal barrier, collar linings, winter liner fabric, and trim shall be individually tested for flame resistance.

D.2 Char length measurement

D.2.1 Char length

The char length shall be the distance from the end of the specimen, which was exposed to the flame, to the end of a tear (made lengthwise) of the specimen through the centre of the charred area.

D.2.2 Measurement procedure

D.2.2.1 The specimen shall be folded lengthwise and creased by hand along a line through the highest peak of the charred area. A hook, made with steel wire, using a 76 mm length of wire and bent 13 mm from one end to form a 45° hook, shall be inserted in the specimen (or a hole 6 mm diameter or less, pinched out for the hook) at one side of the charred area 6 mm from the adjacent outside edge and 60 mm from the lower end. A weight of sufficient mass such that the weight and hook together shall equal the total tearing load required.

D.2.2.2 A tearing force shall be applied gently to the specimen by grasping the corner of the specimen at the opposite edge of the char from the load, and raising the specimen and weight clear of the supporting surface. The end of the tear shall be marked off on the edge and the char length measurement made along the undamaged edge.

D.2.2.3 The specific load applicable to the mass of the test specimen shall be in accordance with values given in Table D.1.

Table D.1

Mass of specimen material before any fire retardant or coating m (g/m^2)	**Total tearing mass for determining the charred length** (kg)
$50 < m \leqslant 200$	0,1
$200 < m \leqslant 500$	0,2
$500 < m \leqslant 800$	0,3
> 800	0,45

Annex E
(normative)

Measurement of water-absorption resistance — Procedure

The following modifications will be used when testing the outer shell for water absorption resistance in accordance with ISO 4920.

The blotter paper shall be weighed before and after the water spray exposure. An analytical balance accurate to 0,01 g shall be used. Measurements of mass shall be made to the nearest 0,01 g. The percent water absorption shall be determined using the following equation:

$$w_{\mathrm{w}} = \frac{m_{\mathrm{f}} - m_{\mathrm{i}}}{m_{\mathrm{i}}} \times 100$$

where:

w_{w} is the water absorbed, expressed as a percentage by mass;

m_{f} is the final mass, expressed in grams, of the blotter paper;

m_{i} is the initial mass, expressed in grams, of the blotter paper.

Annex F
(informative)

A recommended approach and considerations for performing a risk assessment

F.1 General

Personal protective equipment is only one part of an effective system of firefighter safety. Well trained, closely supervised and properly staffed fire departments are equally essential elements of minimizing the operational risk.

Clauses 4 and 5 of this International Standard are taken from EN 469 and NFPA 1971 and represent two similar yet different approaches for structural firefighting protective clothing. These documents probably reflect the fire experience and the firefighter death and injury history of the respective world communities that developed these documents. Both provide for protection of the firefighter but take into account that different fire ground factors and different firefighting operations can exist in various parts of the world.

Regardless of location, the primary goals of firefighting and rescue work are to control an emergency as quickly as possible and at the same time take steps to minimize eventual damage to and loss of materials and persons. In order of priority, the objectives of a firefighter reaching an incident are to:

a) save lives and to prevent or minimize injury;

b) prevent or minimize damage to property;

c) prevent or minimize damage to the environment.

The role of firefighters' personal protective equipment (PPE) is not only to protect the firefighter but also to enable the firefighter to achieve these objectives.

However, in emergency situations where the firefighter is unable to achieve these objectives, the PPE must also provide sufficient protection to enable the firefighter to escape without receiving unacceptable injury. The type of PPE and the protection it offers must be selected on the basis of a risk assessment specific to PPE use for identifying hazards, evaluating those hazards, and selecting specific performance requirements which eliminate or reduce these hazards.

F.2 General approach for conducting a risk assessment

The three major steps of the risk assessment process are as follows.

a) **Risk identification:** for every aspect of the operation of the fire department or brigade, list potential problems and hazards. The following are examples of sources of information that may be useful in this process:

   1) a list of the risks to which members are or may be exposed;

   2) records of previous accidents, illnesses, and injuries, both locally and nationally;

   3) facility and apparatus surveys, inspections, etc.

b) **Risk evaluation:** evaluate each item listed in the risk identification process using the following questions.

   1) What is the level or potential severity of the occurrence?

   2) What is the potential frequency or likelihood of the occurrence?

3) What are the potential consequences of the occurrence?

This will help to set priorities in the developing specifications for PPE performance. Some sources of information which may be useful are:

i) safety audits and inspection reports;

ii) prior accident, illness, and injury statistics;

iii) application of national data to local circumstances;

iv) professional judgement in evaluation risks unique to the jurisdiction.

c) **Risk control:** once the risks are identified and evaluated, a control for each should be implemented and documented. In the case of PPE, this should include determining the appropriateness of specific tests and requirements for eliminating or reducing risk. Normally, the two primary methods of controlling risk, in order of preference, are as follows:

1) wherever possible, totally eliminate and/or avoid the risk or activity that presents the risk;

2) where it is not possible to or practical to avoid or eliminate the risk, steps should be taken to control it (such as developing appropriate PPE specifications).

Specification of appropriate PPE must be part of any overall safety program which includes Standard Operating Procedures, training, and inspections. As with any program, it is important to evaluate whether the plan is working. Periodic evaluations should be made, and if the program elements are not working satisfactorily, then modifications to the program should be made. If the methods are changed, a new risk assessment should be performed.

F.3 Recommended factors for identifying and evaluating firefighter risks

In using this International Standard for purchasing appropriate firefighting clothing, some of the factors which should be considered in a risk assessment, include the following.

a) **Level of firefighter training and experience.** Well-trained and experienced firefighters are more likely to recognize fireground hazards and appropriately respond in ways to minimize their potential for injury. The quality, amount, and frequency of training will also have an impact on the firefighter's potential for injury. Firefighters should be specifically trained in the use of the selected PPE.

b) **Level of fitness and health of the firefighter.** Firefighters who are in good health and physical shape are more likely to respond safely and be less subject to stress-related injuries on the fire ground than firefighters having poor health and physical conditioning.

c) **Function of the firefighter at the incident scene.** Firefighters which make aggressive interior attacks at structural fires may be at more risk for burn injury than firefighters which assume defensive positions outside of burning structures. Some organizations may segregate firefighter responsibilities at the fire scene and subsequently require different levels of protection. Other organizations may require each firefighter to be equipped to perform any function at the fire scene, recognizing the possibility that any individual may be required to respond under emergency conditions. In all cases, the specific activities of firefighters in responding to fires or other emergencies must be accounted for in determining risk of injury. Examples may include equipping firefighters with PPE which is designed for aggressive interior attack as compared to functions where firefighters activities are primarily defensive.

d) **Environmental conditions at the incident scene.** Hot and humid conditions as well as cold conditions can affect firefighter protection at the response scene. In addition, the physical environment in which the response is conducted and its impact on firefighters performing assigned duties must be accounted for. For example, firefighters using hoses may become wet. Water inside clothing systems has both positive and negative impacts on its performance.

e) **Specific hazards to be faced at the incident scene.** Thermal as well as physical and other hazards should be considered in evaluating response risks. The type, level, and duration of heat exposure as well as the physical environment in which it is contained will have a significant effect on the potential risks faced by firefighters. Other hazards such as potential for flame contact, low visibility, fire ground chemicals, and rough physical surfaces are known to create additional risks for injury at the fire scene.

f) **Known limitations of the protective clothing and other PPE.** While protective clothing is designed to prevent or minimize injury, the specific limitations of protective clothing in providing protection under all situations must be recognized. Clothing performance may be limited based on certain design features or material performance characteristics. In addition, these characteristics may be diminished as the clothing is worn. Protective clothing must be properly maintained to ensure continued performance. Methods for integrating other PPE such as helmets, gloves, boots, and self-contained breathing apparatus must be done in a manner that provides complete protection to the wearer.

g) **Type and application of command system at the incident scene.** The amount of discipline and coordination of firefighters at the accident/response scene can impact the risk for injury. Firefighters which have well-defined responsibilities and are closely supervised are less likely to be injured as compared to firefighters which act more independently and in a less coordinated fashion.

Consideration should also be given to the build up of heat stress by prolonged use of the PPE in firefighter and associated activities. Heat stress and other stress-related injuries are one of the more frequent causes of firefighter fatalities and injuries. Heat stress is affected by a number of factors which include all of the factors described above.

F.4 Other considerations

No matter where in the world firefighting operations take place, firefighters are exposed to a number of conditions. These conditions include exposure to heat and products of combustion from the interior of structures or other areas where there can be an increase in fire volume, with the ignition of fire gases, causing a flash over. Firefighters who are confronted with these conditions will face the same exposure regardless of type of building construction and general firefighting strategy. No structural firefighting protective equipment can give prolonged protection from such hostile conditions. Certain injury, and quite possibly death, will occur if firefighters do not quickly extricate themselves from these severe exposures.

The community disposition towards fire protection plays a key role in the planned deployment of firefighting operations. Fire departments and brigades over the world develop strategy and operating procedures that reflect the nature of the fire hazard in their community and the available resources dictate their level of intervention. Where fire protection is a key objective of the community and is reflected in community planning and through their regulations, building codes, and use of built-in and monitored automatic detection and suppression systems these communities should not experience many severe fires. Where fires do occur, interior operations will probably be conducted in the incipient fire stage where danger to interior firefighting operations is low. Well-managed, highly-trained, closely-supervised, and properly-staffed fire departments and brigades will perform effectively to minimize the economic loss to the community and provide risk management to enhance operational safety.

Building construction can be a very important factor affecting interior firefighting operations. Where buildings are of compartmentalized fire-resistive construction, fires can be expected to be confined by the building design to the areas of origin or within a building “compartment”. In such situations, fire might be allowed to burn itself out while confined to the area or room of origin without direct firefighting intervention, or less aggressive firefighting operations might be used resulting in firefighters being exposed to a less hostile thermal environment.

In communities where water supplies for firefighting are weak, or where buildings are relatively small and well spaced, or where the fire department or brigade is not well organized, extensively trained, properly staffed, supervised, or does not have adequate resources for interior firefighting operations, exterior firefighting operations may work effectively for that community provided the fire department or brigade is not required or expected to perform interior search and rescue functions. Such exterior operations do not require as high a level of protective equipment as interior operations do.

Other communities do not have extensive fire-resistive construction and many buildings are built of combustible materials. In many situations, such buildings are built closely together and uncontrolled fire can extend from building to building. Many fire departments or brigades are also expected to extend interior search and rescue operations into all uninvolved areas of the fire building to locate and remove any endangered occupants. Where the fire department or brigade is expected to perform interior search and rescue operations, and is expected to minimize the economic loss to the community by confining the fire to the smallest area possible, firefighters will be exposed to hostile thermal environments while performing their tasks. Such operations call for an aggressive interior attack to achieve the objectives in as little time as possible. Protective clothing for firefighters performing such operations should afford optimum protection.

In many fire departments and fire brigades, specific personnel will be assigned to interior firefighting operations, while others will be assigned to tasks that do not bring the firefighters into interior operating positions being affected by the fire. Such fire departments or brigades might choose to provide the “interior attack team” with a higher level of protective clothing than personnel assigned to other duties.

Other fire departments and brigades might require that all firefighters be able and available to perform “interior attack team” operations at any incident or at any time during an incident. In these situations, perhaps all firefighters need to be regularly equipped with the higher level of protective clothing.

In all cases, the community must be clear in what is expected of their fire department or brigade in terms of its mission and objectives to be met. The fire department or brigade must properly define for the community and for itself what levels of organization, supervision, training, staffing, and resources are necessary to effectively and safely perform the operations to achieve the objectives. Part of this process will identify the hazards of the various operations and what the appropriate protective clothing and equipment should be.

A current point of view about firefighting protective clothing is that it allows firefighters to “overextend” themselves, thus getting themselves into more dangerous situations than they would if they were not wearing such “sophisticated” equipment or advanced protective clothing which does not allow them to “feel the heat” and better judge their environment. Firefighters who “overextend” themselves are probably not operating under close supervision or in an incident command system that controls the position, function, and safety of all operating teams. Nonetheless, protective clothing can allow firefighters, operating safely within the incident command system, to be able to perform more effectively. Regardless of the level of protection afforded by any clothing, anything except bare skin can allow firefighters to “overextend” further enforcing the position that all operations must be managed by the incident command system and that firefighters only operate under direct supervision within that system.

The ability to judge heat build-up can differ depending on what the firefighter is wearing. It is actually a training issue for the firefighter to become familiar as to how a particular ensemble transmits heat. What may be felt in one garment may be entirely different in another garment. There is not a single “measure of heat building up” that can be applied to all garments. Moreover, it is not practical to rely on exposed human body parts to indicate heat exposure as second degree burns occur at relatively low temperatures (about 55 °C) after short exposure.

Another current viewpoint is that the thermal insulation of the protective clothing causes more injuries, due to heat stress, than lighter weight (but less protective) garments. Incorrect conclusions have been drawn about reported stress-related injuries and deaths. Some positions state that these injuries are the consequences of wearing protective clothing. Heat stress cannot be addressed only by the garment but must be approached from several factors that equally affect it. The total factors affecting stress and heat stress must be evaluated including firefighters’ age, physical condition, individual metabolism; as well as how firefighters are managed and if their physical conditions are monitored and cared for during incident operations. Although it is true that lighter garments will most likely help to reduce the stress to the wearer, lighter garments that provide the minimum protection specified by the International Standard should be selected. The entire spectrum of heat stress and stress-related problems must be fully addressed by the fire department or brigade. Practices for ventilating firefighters (by opening clothing), replacement of fluid, and other rehabilitation measures should be considered in the reduction of heat stress.

With any selection of protective equipment, fire departments and fire brigades must carefully review their needs and determine what will be an appropriate level of protection. Purchase specifications should reflect these needs and should specifically require compliance with the applicable standard. This International Standard should not be construed as setting levels of protection for all firefighting situations and conditions to which firefighters may be exposed.

Annex G
(informative)

Comparison of European (clause 4) and North American (clause 5) requirements

Requirement	**European Approach — Clause 4** (see subclause)	**North American Approach — Clause 5** (see subclause)
Flame resistance	In accordance with EN 532, performed on surface of component assembly, undergarments, and wristlets after five laundering cycles: no hole formation, flaming/molten debris, afterflame time, afterglow $\leqslant$ 2 s (4.4.1)	In accordance with ISO 15025 and annex D, performed on edge of individual layers in protective garment composite, protective hoods, and protective wristlets before and after five laundering cycles: no melting or dripping, afterflame time $\leqslant$ 2 s, char length $\leqslant$ 102 mm (5.4.2.1, 5.5.2, 5.6.2)
Heat transfer (flame exposure)	In accordance with ISO 9151 using flame exposure only, performed on component assembly after five laundering cycles: $I_{Q,24} \geqslant 13$ and $(I_{Q,24} - I_{Q,12}) \geqslant 4$ (4.4.2)	In accordance with ISO 17492 using combined flame and radiant heat exposure, performed on composite, protective hood and protective wristlet before and after five laundering cycles: Time-to-burn $\geqslant$ 17,5 s for protective garment (5.4.1.1), $\geqslant$ 10 s for both protective hood and wristlet (5.5.1 and 5.6.1)
Heat transfer (radiant exposure)	In accordance with method B of ISO 6942:1993, performed on component assembly after five laundering cycles: $t_2 \geqslant 22$ s and $(t_2 - t_1) \geqslant 6$ s (4.4.3)	Radiant heat exposure part of ISO 17492 above
Residual strength of material when exposed to radiant heat	In accordance with ISO 5081 after exposure to method A of ISO 6942:1993 at 10 kW/m^2, performed on outer material: tensile strength $\geqslant$ 450 N (4.4.4)	No equivalent requirement
Heat resistance	In accordance with annex A at 180 °C for 5 min, performed on each layer of component assembly: no melting, dripping, or ignition; shrinkage $\leqslant$ 5 % (4.4.5)	In accordance with ISO 17493 at 260 °C for 5 min, performed on all protective garment, hood, wristlet materials excluding trim, elastic, and hook and pile fastener before and after five laundering cycles: no melting, separation, or ignition; shrinkage $\leqslant$ 10 % (5.4.2.2, 5.4.2.3, 5.5.3, 5.5.4, 5.6.3, 5.6.4)
Char resistance	No equivalent requirement	In accordance with ISO 17493 at 260 °C for 5 min, performed on outer shell before and after five laundering cycles: no char (5.4.3.2)

Requirement	European Approach — Clause 4 (see subclause)	North American Approach — Clause 5 (see subclause)
Tensile strength	In accordance with ISO 5081, performed on outer material: tensile strength ⩾ 450 N (4.4.6)	No equivalent requirement
Tear resistance	In accordance with method A2 of ISO 4674:1977 (“tongue” or “trouser” tear method) performed on outer material: tear strength ⩾ 25 N (4.4.7)	In accordance with ISO 9073-4 (“trapezoidal” tear method), performed on outer shell, moisture barrier, thermal liner, and winter liner: tear strength ⩾ 100 N for outer material (5.4.3.1), tear strength ⩾ 22 N for moisture barrier (5.4.4.1), thermal liner (5.4.5) and winter liner (5.4.6)
Surface wetting (water absorption resistance)	In accordance with ISO 4920, performed on outer material: spray rating ⩾ 4 (4.4.8)	In accordance with ISO 4920 and annex E, performed on outer shell before and after five laundering cycles: percent absorption ⩽ 30 % (5.4.3.3)
Cleaning shrinkage resistance	In accordance with ISO 5077, performed on outer garment assembly following five laundering cycles: shrinkage ⩽ 3 % (4.4.9)	In accordance with ISO 5077, performed on each layer of the composite, protective hoods, and protective wristlets following five laundering cycles: shrinkage ⩽ 5 % (5.4.2.4, 5.5.5 and 5.6.5)
Liquid chemical penetration resistance	In accordance with ISO 6530, performed component assembly: run-off ⩾ 80%, no penetration to innermost layer (4.4.10)	No equivalent requirement
Water penetration resistance	Optional in accordance with ISO 811, performed on component assembly (4.4.11)	High pressure in accordance with ISO 811, performed on moisture barrier before and after five laundering cycles: resistance ⩾ 172 kPa (5.4.4.2); Low pressure in accordance with ISO 811, performed on moisture barrier and seams before and after five laundering cycles: resistance ⩾ 7 kPa (5.4.4.3)
Breathability (total heat loss)	Optional in accordance with ISO 11092, performed on component assembly (4.4.11)	Optional in accordance with the modified form of ISO 11092 under non-isothermal conditions as specified in annex B, performed on composite (5.4.1.3)
Seam strength	No equivalent requirement	In accordance with ISO 5082, performed on all garment seams; major A seams (outer shell) ⩾ 675 N; major B seams (moisture barrier and thermal liner) ⩾ 337 N; and minor seams (other seams) ⩾ 180 N (5.4.1.2)

Requirement	**European Approach — Clause 4** (see subclause)	**North American Approach — Clause 5** (see subclause)
Thread heat resistance	No equivalent requirement	In accordance with ISO 3146, performed on protective garment, hood, and wristlet thread: no ignition, melting, or charring (5.4.7, 5.5.6, and 5.6.6)
Trim visibility	No equivalent requirement	In accordance with ASTM E 809 and annex C performed on protective garment trim: coat total area: $C_l \geqslant 25$ cd/lx (270 cd/foot-candle) (5.4.8); pant total area: $C_l \geqslant 7$ cd/lx (75 cd/foot-candle) (5.4.8)
Hardware corrosion resistance	No equivalent requirement	In accordance with ISO 9227 with 5 % saline solution for 20 h, performed on all protective clothing hardware: no corrosion of base metal, no more than light surface type corrosion or oxidation (5.4.9.2)
Hardware heat resistance	No equivalent requirement	In accordance with annex A at 260 °C for 5 min, performed protective clothing hardware: no ignition, must remain functional (5.4.9.3)
Overall garment testing	Optional testing at one of three conditions and exposure times: visual inspection of garment (4.5)	No equivalent requirement

Bibliography

[1] EN 469:1995, *Protective equipment for firefighters — Requirements and test method for protective clothing for firefighting*.

[2] ISO 11092:1993, *Textiles — Physiological effects — Measurement of thermal and water-vapour resistance under steady-state conditions (sweating guarded-hotplate test).*

[3] NFPA 1971:1991, *Standard on protective clothing for structural fire fighting.*

[4] NFPA 1500:1992, *Standard on Fire Department Occupational Safety and Health Program.*

[5] NFPA 1975:1994, *Standard on station/work uniforms for firefighters.*

ICS 13.340.10

Price based on 37 pages